land

Supplementary Information

Dynamic Changes of Nitrogen Loads in Source–Sink Landscapes under Urbanization

The calculation of N load

- **Cropland land**

Input

Chemical fertilizer $C_{fertilizer}=F_1\times R_1+F_2$

BNF $C_{BNF}=F_4\times R_2+(F_3-F_4)\times R_3$

Deposition $C_{deposition}=F_5\times R_4$

Seed $C_{seed}=F_6\times R_5\times R_6$

Irrigation water $C_{irrigation}=F_5\times R_7$

Manure to field $C_{animal\ manure}=F_7\times R_8\times R_9/365\times R_{10}$

$C_{human\ manure}=H_{excreta}\times(1-R_{21})\times R_{11}\times(1-R_{22})$

Crop residue $C_{crop\ residue}=F_9\times(1/R_{12}-1)\times R_{13}\times R_{14}$

Output

Crop harvest $C_{crop\ harvest}=F_9/R_{12}\times R_{23}$

NH3 $C_{NH_3}=C_{fertilizer}\times R_{22}+(C_{animal\text{-}manure}+C_{human\text{-}manure})\times R_{21}$

Surplus $C_{surplus}=C_{input}-C_{NH_3}-C_{crop\text{-}harvest}$

Denitrification(N_2) $C_{denitrification}=C_{surplus}\times R_{15}$

Denitrification (N_2O) $C_{denitrification\text{--}N_2O}=C_{denitrification}\times R_{18}/(1+R_{18})$

N_2O $C_{N_2O}=(C_{manure}+C_{crop\ residue})\times R_{16}+C_{fertilizer}\times R_{17}+C_{denitrification\text{-}N_2O}$

Leach $C_{leach}=C_{surplus}\times R_{19}$

Runoff $C_{runoff}=(C_{fertilizer+}C_{BNF}+C_{manure}+C_{crop\text{-}residue})\times R_{20}\times R_{24}$

- **Forest land**

Input

Deposition $GR_{depositon}=F_{10}\times R_4$

BNF $GR_{BNF\text{-}forest}=F_{10}\times(R_{25}+R_{26})$

Litter $GR_{depositon}=F_{10}\times R_{27}$

Output

Runoff (forest) $GR_{runoff\text{-}forest}=GR_{input}\times R_{28}$

Denitrification(forest) $GR_{denitrification}=F_{10}\times R_{29}$

- **Greenbelts and park land**

Input

Fertilizer $GR_{fertilizer}=F_{11}\times R_{30}$

Pet-excreta $GR_{pet-extreta} = F_{12}/R_{31} \times \left[(R_{32} \times R_{33} \times R_{34})/R_{35} + (R_{36} \times R_{37} \times R_{38})\right]$

Deposition $GR_{depositon} = F_{11} \times R_4$

BNF (lawn) $GR_{BNF\text{-}lawn} = F_{11} \times R_{39}$

Irrigation $GR_{depositon} = F_{11} \times R_{40} \times R_{41}$

Output

Runoff(lawn) $GR_{runoff\text{-}lawn} = GR_{fertilizer} \times R_{42} + GR_{pet\text{-}excreta} \times R_{43}$

Leach $GR_{leach} = GR_{input} \times R_{44}$

NH_3 $GR_{NH_3} = GR_{fertilizer} \times R_{45} + GR_{pet} \times R_{46}$

N_2O $GR_{N_2O\text{-}lawn} = GR_{fertilizer} \times R_{47}$

N_2 $GR_{N_2\text{-}lawn} = GR_{fertilizer} \times R_{48} + GR_{pet\text{-}excreta} \times R_{49}$

- **Residential land**

Output

Sewage $R_{sewage} = F_{13} \times R_{50} \times R_{51}$

Garbage $R_{garbage} = F_{14} \times R_{52} \times R_{53}$

N_2O: The N_2O emission mainly come from energy consumption of residents, so the calculation refers to equation of traffic land.

NO_x: The NO_x emission mainly come from energy consumption of residents, so the calculation refers to equation of traffic land.

- **Traffic land**

Output

NO_X $E_{NO_X} = (1\text{-}R_{54}) \times F_{15} \times R_{55}$

N_2O $E_{N_2O} = F_{15} \times R_{56} \times R_{57}$

NH_3 $E_{NH_3} = F_{16} \times R_{58}$

- **Industrial land**

$I_{output} = I_{NO_X} + I_{N_2O} + I_{sewage}$

These data were taken directly from local statistical offices.

Table S1. The parameters of N load calculation.

NO.	Item Description	Unit	Value	Ref
R1	N content of compound fertilizer	%	33.3	[2]
R2	Symbiotic N-fixation rate of cropland	kg/ha	Legumes:105; peanut:112	[3]
R3	Non-symbiotic N-fixation rate of cropland	kg/ha	18.75	[3]
R4	N deposition rate	kg/ha	30.15	[4]
R5	Seed rate	kg/ha	Rice:37.5; soybean:76.05; potatoes:225;peanut:285;rapeseed:1;sesame:5;vegetables:15.38	[5]

R6	N content of seed	%	Cereal:1.3;potatoes:0.3;soybean:4.2;peanut:4.4;rapeseed:4;sesame:3.49;sugarcane:0.13;vegetables:0.2;furits:0.21	[5]
R7	Irrigation rate	kg/ha	26.3	[6]
R8	N excreta rate for animals	kg/cap	Pig:8; cattle:40; sheep:5; rabbit:0.4; poultry:0.3	[7]
R9	Feeding period of livestock	day	Pig:199;cattle:365;sheep:365;rabbit:120; poultry:55	[7]
R10	Ratio of animal excreta back to field	%	Pig:60;cattle:77.7;sheep:70; rabbit:35; poultry:39	[7]
R11	Ratio of human excreta back to field	%	urban :10; rural :30	[7]
R12	Harvest Index of crops		Cereal:0.53; potatoes:0.66; soybean:0.5; peanut:0.55; rapeseed:0.28; sesame:0.37; sugarcane:0.67;	[7]
R13	N content of straws	%	Cereal:0.91; potatoes:2.51; soybean:2.1; peanut:1.82; rapeseed:0.87; sesame:1.31; sugarcane:1.1;	[7]
R14	Ratio of straw back to field	%	Cereal:41.7; potatoes:50; soybean:16.8; peanut:26; rapeseed:47.6; sesame:0; sugarcane:10;	[7]
R15	Denitrification percentage (N_2)	%	72.5	[8]
R16	Direct N_2O emission factor from chemical fertilizer	%	0.86	[9]
R17	Direct N_2O emission factor from organic fertilizer		0.01	[10]
R18	N_2O-yield ratio of denitrification	Kg/N_2	0.039	[11]
R19	Leaching ratio of applied N	%	12.5	[12]
R20	Runoff ratio of applied N	%	16.7	[8]
R21	Volatilization coefficient of excreta	%	Pig:19; cattle:17; sheep:25; rabbit:54; poultry:22; human:25	[13]
R22	Volatilization coefficient of chemical fertilizer	%	20	[14]
R23	N content of crop	%	Cereal:1.12; potatoes:1.04; soybean:3.15; peanut:3.25; rapeseed:1.75; sesame:2.12; sugarcane:0.37;vegetables:0.3;furits:0.19	[15]
R24	The retention coefficient of N runoff	%	42.5%	[16]
R25	Symbiotic N-fixation rate of forest	kg N ha-1 yr-1	5	[19]
R26	Non-symbiotic N-fixation rate of forest	kg N ha^{-1} yr^{-1}	12	[19]
R27	Litter return to forest	kg N ha^{-1} yr^{-1}	47.63	[17]

R28	Rate of N runoff in forest	%	22	[19]
R29	Factor of denitrification in forest	kg N ha^{-1} yr^{-1}	3.3	[18]
R30	Fertilizer rate of greenbelts and park	kg N ha^{-1} yr^{-1}	300	[20]
R31	The percentage of people who own pets		1/13	Field survey
R32	The proportion of the cat	%	30.8	[21]
R33	The weight of cat	kg	3.6	[22]
R34	The per kilogram of cat needs nitrogen for per day	g/kg	0.88	[22]
R35	The landfill percentage of pet excretion	%	50	[22]
R36	The proportion of the dog	%	69.2	[21]
R37	The weight of dog	kg	20	[22]
R38	The per kilogram of dog needs nitrogen for per day	g/kg	0.56	[22]
R39	Nitrogen fixation rate of lawn	kg N ha^{-1} yr^{-1}	18	[22]
R40	irrigation water volume	L/ha	10500000	Field survey
R41	nitrogen concentration of irrigation water	mg/L	20	Field survey
R42	Rate of fertilizer nitrogen runoff in greenbelts and park	%	11	[19]
R43	Rate of manure nitrogen runoff in greenbelts and park	%	5	[19]
R44	Factor of leaching from greenbelts and park	%	3.2	[23]
R45	Factor of NH_3 emission from fertilizer	%	11.8	[19]
R46	Factor of NH_3 emission from manure	%	23	[19]
R47	Factor of N_2O emission in greenbelts and park	%	1.1	[19]
R48	Factor of N_2 from fertilizer	%	25.3	[24]
R49	Factor of N_2 from manure	%	15	[24]
R50	nitrogen concentration of sewage	kg/t	0.0468	[25]
R51	treatment rate of sewage	%	94	Field survey
R52	The percentage of various types of garbage	%	Foodwaste:51.5; papers:9.3; plastics:15; textile:5.1Woods:2; glasses:2.9; metals:0.7; dust:13.5	[26]
R53	The N content of garbage	%	Foodwaste:2.6; papers:0.3; plastics:0.5; textile:10 Woods:0.3; glasses:0.1; metals:0.1; dust:0.98	[26]
R54	Removal rate of NO_X	%	30	[27]

R55	Factor of energy sector NO_x-N emission	Kg/t	TableS3	[27]
R56	Factor of energy sector N_2O emission	kg/TJ	TableS4	[28]
R57	Conversion of fuel calorific value	kJ/kg; kJ/m^3	TablesS5	[28]
R58	Factor of vehicle-miles of travel NH_3 emission	g/km	TableS6	[29]

Table S2. The activity data of N load calculation.

No.	Item Description	Unit	Ref
F1	Consumption of nitrogenous fertilizer	T	[1]
F2	Consumption of compound fertilizer	T	[1]
F3	Total sown area	ha	[1]
F4	Sown area of legume crops	ha	[1]
F5	Area of cropland	ha	[1]
F6	Sown area of different crops	ha	[1]
F7	Number of livestock and poultry		[1]
F8	Population (count)		[1]
F9	Yield of grain crops	T	[1]
F10	The area of forest	ha	[1]
F11	The area of greenbelts and park	ha	[1]
F12	The population of city		[1]
F13	Volume of sewage	m^3	[1]
F14	Amount of household garbage	T	[1]
F15	Energy consumption of various sector	T	[1]
F16	The amount of various vehicle		[1]

Table S3. Factor of energy sector NO_x emission(kg/t).

Sector	Emission source	Coal	Coke	Crude oil	Gasoline	Kerosene	Diesel	Fuel oil	Natural gas
Energy	Electric	9.95		7.24	16.7	21.2	7.4	10.06	41
	Manufacture	0.75	0.9	2.19			9.62	5.84	
	Oil refining	0.37		0.24					
Construction		7.5	9		16.7	7.46	9.62	5.84	20.9
Transportation	Highway				21.2	27.4	27.4	27.4	
	Railway	7.5	9				54.1	54.1	
	others	7.5	9	5.09	16.7	27.4	36.3	36.3	20.9
Consumption		1.88	2.25	1.7	16.7	2.49	3.21	1.95	14.6
Commerce		3.75	4.5	3.05	16.7	4.48	5.77	3.5	14.6
Agriculture		3			6.7		9.4		
others		3.75	4.5	3.05	16.7	4.48	5.77	3.5	14.6

Table S4. Factor of energy sector N_2O emission（kg/TJ）.

Sector	Coal	Coke	Crude oil	Gasoline	Kerosene	Diesels	Natural gas
Consumption	1.5	1.5	0.6	0.6	0.6	0.6	0.1
Transportation				3.2	2	3.9	0.1
Agriculture	1.5	1.5	0.6	0.6	0.6	0.6	0.1
Construction	1.5	1.5	0.6	0.6	0.6	0.6	0.1
Commerce	1.5	1.5	0.6	0.6	0.6	0.6	0.1

Table S5. Conversion of fuel calorific value (kJ/kg; kJ/m^3).

Item	Lower calorific value
Coal	20908
Coke	28435
Coal gas	16726
Crude oil	41816
Gasoline	43070
Kerosene	43070
Diesel	42652
Fuel oil	41816
Natural gas	38931

Table S6. Factor of vehicle-miles of travel NH_3 emission.

	Factor of NH_3 emission g/km
Heavy-duty car	0.028
light car	0.026
Heavy-duty diesel car	0.017
Light diesel car	0.017

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